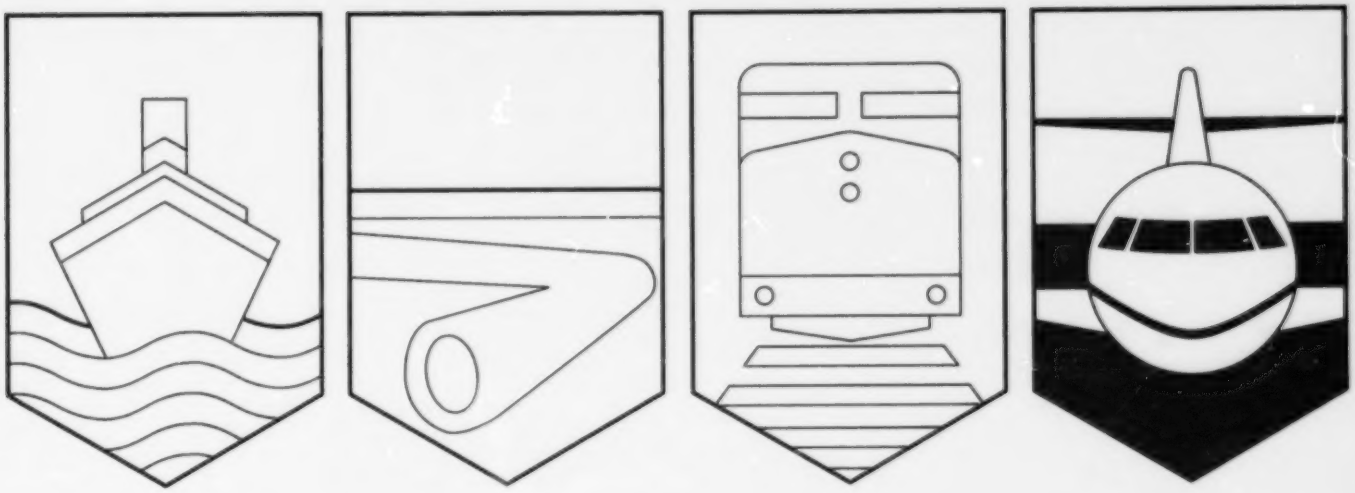
Canadian Transportation
Accident Investigation
and Safety Board

Bureau canadien d'enquête
sur les accidents de transport
et de la sécurité des transports



AVIATION OCCURRENCE REPORT

PERIMETER AIRLINES LTD
BEECH A65 QUEEN AIR C-GKDX
WINNIPEG, MANITOBA
31 July 1987

REPORT NUMBER 87-C70061

Canada

The Canadian Transportation Accident Investigation and Safety Board investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

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SYNOPSIS

Perimeter Airlines Flight 117 departed runway 13 at Winnipeg International Airport on a visual flight rules flight to Berens River, Manitoba. After turning to the outbound heading, the pilot advised that one engine was inoperative. Shortly thereafter, the aircraft was seen to enter a spin and crash through the roof of a one-storey office building. The aircraft was destroyed, but all five occupants of the aircraft survived; the pilot and two of the passengers were severely injured, and an office worker who was pinned beneath the wreckage received serious injuries.

The Canadian Transportation Accident Investigation and Safety Board determined that the pilot was unable to maintain flying speed while operating the aircraft on one engine. A vibration induced by a fractured flange attachment bolt probably led the pilot to feather the left engine.

8 May 1990

Ce rapport est également disponible en français.

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1.0 FACTUAL INFORMATION

1.1 History of the Flight

Perimeter Airlines Flight 117, a scheduled Class II service, departed Winnipeg on a visual flight rules (VFR)* flight to Berens River, Manitoba, at 0846 central daylight time (CDT)** on 31 July 1987. On board were the pilot and four passengers as well as a load of mail and other cargo. The aircraft was cleared for departure from runway 13, and the flight was cleared for a left turn on course. Shortly after the completion of the turn, at an altitude of about 500 to 600 feet above ground level (agl)***, the pilot advised that the left engine was "out." Approximately one minute later, the aircraft crashed into a one-storey office building, 3/4 of a mile from the airport (see Appendix A).

The accident occurred at 0848 CDT during the hours of daylight at lat 49°55'N, long 97°11'W, at an elevation of 783 feet above sea level (asl).

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	-	-	-	-
Serious	1	2	1	4
Minor/None	-	2	-	2
Total	1	4	1	6

1.3 Damage to Aircraft

The aircraft was substantially damaged.

1.4 Other Damage

The office building and its contents were damaged when the aircraft crashed through the roof and continued downward to ground level.

* See Glossary for all abbreviations and acronyms.

** All times are CDT (Coordinated Universal Time (UTC) minus five hours) unless otherwise stated.

*** Units are consistent with official manuals, documents, reports, and instructions used by or issued to the pilot.

1.5 Personnel Information

	Pilot-In-Command
Age	25
Pilot Licence	Commercial
Medical Expiry Date	01 April 1988
Total Flying Time	1,728 hr
Total on Type	292 hr
Total Last 90 Days	410 hr
Total on Type Last 90 Days	290 hr
Hours on Duty Prior to Occurrence	1
Hours off Duty Prior to Work Period	16

The pilot was qualified and held a valid licence with a Class I instrument rating. He was hired by Perimeter Aviation in late May 1987 and flew a Beech 65 for the first time on 24 May 1987. He completed a two-hour training flight on that date and a further 2.2 hours on 25 May, prior to successfully completing his proficiency check with a Transport Canada flight inspector. The pilot had a total of 646 hours flying time on multi-engined aircraft.

1.6 Aircraft Information

Manufacturer	Beech Aircraft Corp.
Type	A65 Queen Air
Year of Manufacture	1967
Serial Number	LC-271
Certificate of Airworthiness	04 September 1987
Total Airframe Time	15,253 hr
Engine Type (2)	Lycoming IGSO-480
Propeller Type (2)	Hartzell HC-B3Z20-2A
Maximum Allowable Take-off Weight	8,200 lb
Recommended Fuel Type	100/130 Aviation Gas

According to the aircraft technical log books, maintenance had been carried out as prescribed and there were no outstanding unserviceabilities prior to the flight. The right engine vacuum pump had been changed twice in the previous month. Since overhaul, the left and right engines had accumulated 1,421.3 and 570.5 hours respectively. The engines were due for scheduled overhaul at 2,000 hours.

The aircraft gross weight at take-off was 8,135 pounds, 65 pounds below the maximum allowable. The centre of gravity was within the prescribed limits.

1.7 Meteorological Information

The Winnipeg weather reported at 0900 CDT was as follows:

> Measured ceiling 2,900 ft overcast; visibility 15 mi in very light rain showers; temperature 23°C, dew point 20°C; and wind from 120° at 15 gusting to 26 kt.

The wind caused mechanical turbulence that resulted in turbulent flight conditions at low altitude.

1.8 Aids to Navigation

Not pertinent.

1.9 Communications

Communications with the controlling agency were normal.

1.10 Aerodrome Information

Winnipeg International Airport is owned and operated by Transport Canada. It has three asphalt-surface runways and is situated at lat 49°54'39"N, long 97°14'34"W, at a reference elevation of 783 feet asl. Runway 13, the departure runway for this flight, measures 8,700 feet long by 200 feet wide.

1.11 Flight Recorders

The aircraft was not equipped with a flight data recorder or a cockpit voice recorder, nor was either required by regulation.

1.12 Wreckage and Impact Information

From impact marks, it was determined that the aircraft was in a 35- to 40-degree nose-down attitude and spinning to the left when it struck and crashed through the roof of the building. The landing gear and flaps were in the up position. The left propeller was feathered, and witnesses reported hearing the sound of an engine operating at high power prior to impact.

The left magneto switch was found in the OFF position. It was not possible to determine the position of the engine controls at impact, as these had been disturbed

when the injured were being extricated from the wreckage. However, when the pilot transmitted to the control tower, the landing gear warning horn could be heard in the background, indicating that a throttle had been retarded.

All aircraft control surfaces were accounted for at the crash site, and the engines were removed for examination. No airframe structural failures were found beyond those attributable to the collision with the building.

1.13 Medical Information

The pilot held a valid Category I medical and was fit. He had rested or slept during the 16-hour off-duty period prior to the accident flight. The pilot sustained a severe head injury and has no recollection of the events leading up to, and including, the accident.

1.14 Fire

There was no evidence of fire either before or after the occurrence.

1.15 Survival Aspects

The accident was survivable. The forces of the low-velocity impact were attenuated as the aircraft crashed through the roof of the building. Crash rescue, fire-fighter, and medical personnel were on the scene within minutes of the occurrence. Two passengers occupying a bench seat on the right side of the aircraft received minor injuries and crawled from the wreckage unaided. The pilot and the two other passengers, as well as an office worker who was pinned beneath the wreckage, received serious injuries. All aircraft occupants were wearing lap-type seat-belts.

1.16 Tests and Research

The right engine was disassembled and examined. There was no evidence of malfunction, and it was considered capable of producing full power.

The left propeller governor was tested and found to be functional. The left engine was disassembled, and examination revealed that the left supercharger impeller had been damaged by a foreign object. The

impeller had sustained severe damage to the blade leading edges, and there was evidence of rub at the blade tips. The cause of the damage could not be determined with certainty, but it was determined to have occurred some time prior to the accident flight. There was no evidence of any metallic foreign object found in the impeller vanes; the most probable source of the damage was determined to be intake ice breaking free and striking the impeller.

The effect of the impeller damage would be to disrupt supercharger airflow to some extent and to produce high-frequency vibrations. These vibrations would not have been apparent to the pilot.

The main bearings and the main oil and scavenge pump bodies and gears were severely worn and scored; the connecting rod bearings were lightly worn and scored. The severe wear and scoring were attributed to particles from a damaged cylinder which had been replaced the evening before the accident. The replacement was necessary because an exhaust guide had failed, resulting in the engine running rough during the previous flight. The bottom three quarters of the exhaust guide was found to be missing, and this material had entered the engine oil pan through the rocker drain tubes. The oil screens and sumps were not inspected for any foreign objects as is standard industry practice. The wearing and scoring were not considered sufficient to have resulted in a power loss during the accident flight.

The reduction gearing which drives the propeller shaft is contained in a magnesium housing bolted to the front of the crankcase. The unit consists of a planetary gear assembly mounted on the propeller shaft and driven by a ring gear mated to the crankshaft flange. Eight bolts fasten the ring gear to the crankshaft flange. The bolts, besides transmitting the engine torque to the propeller shaft, ensure that the diametric and concentric position of the flange to the ring gear is maintained. Galling and fretting between these two mating surfaces confirmed that movement had taken place.

Examination showed that one of the bolts had failed as a result of pre-cracking due to vibrational stress. The cause of the stress could not be determined. The failed section of the bolt and the rear housing of the pinion cage were battered and polished.

1.17 Additional Information

1.17.1 Pilot Flight Time

The pilot had logged 410.1 flight hours in the 90-day period prior to the accident. The following is a breakdown of the pilot's flight time since beginning employment with the company on 24 May 1987.

Date			Flight Time
May 24 - May 31	Inclusive		26.8 hours
June 01 - June 30	"		184.8 "
July 01 - July 30	"		160.7 "

The pilot logged a total of 372.3 hours in 67 days. Except for 05 and 17 July, he flew every day since joining the company.

The crew flight-time limitations as specified in the company operations manual are 120 hours in any 30 consecutive days, 300 hours in any 90 consecutive days and 1,200 hours in any year. These followed suggested Transport Canada limitations which became mandatory about the time of the accident. The manual further states that it is the responsibility of the Chief Pilot to schedule flight crews so as not to exceed flight-time limitations.

1.17.2 Chronic Fatigue

Chronic fatigue in flight crew is fatigue that results from the accumulation of long flight and duty times over an extended period. Chronic fatigue can result in slowed reaction times, inattention, degraded coordination, preoccupation, increased error rate, and complacency. Due to its insidious nature, individuals may not recognize the symptoms, and the condition may not be readily evident to others.

There is general agreement in the aviation community that an effective method of reducing chronic fatigue as a hazard to aviation is to impose flight- and duty-time limitations.

1.17.3 Single-Engine Performance

For the atmospheric conditions existing that day, the manufacturer's single-engine performance charts in the Pilots' Operating Manual indicate that, with the inoperative engine feathered and maximum continuous power applied, the aircraft should have been able to climb at a rate of 120 feet per minute. Further

analysis revealed that, at 15 degrees angle of bank and in the same conditions, the aircraft should have been capable of maintaining level flight. However, the charts assume smooth air flight, with the landing gear and flaps in the up position.

Experienced Queen Air pilots have stated that, given the existing conditions on the day of the accident, the pilot would have had to react quickly and pay particularly close attention to airspeed and aircraft control to achieve the charted performance.

Vmc (airspeed below which directional control cannot be maintained) is determined by the manufacturer as the minimum airspeed at which it is possible to recover directional control of the airplane with one engine out and maximum power on the good engine, and then to maintain straight and level flight, with not more than five degrees of bank. A change in the bank angle will affect the Vmc speed. Banking the aircraft away from the good engine will increase Vmc at a rate of approximately three knots per degree of bank angle. In various sections of the manual, Vmc speeds are stated in both calibrated and indicated airspeed.

Single engine stall data are not stated in the Pilots' Operating Manual for the Queen Air; nor is there any description of the single engine power-on stall characteristics and recovery techniques. This information is not normally published in the Pilots' Operating Manuals for this category of aircraft. The stall characteristics during the single engine operation are considerably more severe than those during symmetrical power operations. Stalling the aircraft when operating in a single engine configuration will result in an increased roll rate toward the dead engine and the progression to an upright spin if immediate recovery action is not taken.

2.0 ANALYSIS

2.1 Introduction

The aircraft crashed through the roof of a building shortly after the pilot advised that the left engine was "out." The analysis focuses on the cause of the power loss and the pilot's reactions to the emergency.

2.2 Loss of Power

The pilot had radioed that the left engine was "out", and evidence was conclusive that he had feathered the propeller.

The supercharger impeller damage was probably the result of intake icing which had occurred on some previous flight. Weather conditions at the time of the accident were not conducive to icing. The out-of-balance condition of the supercharger impeller was considered a possible source of a vibration that might have motivated the pilot to secure the engine. However, because the vibration induced by this condition would be of a very high frequency, it would have been absorbed within the engine and would not have been evident to the pilot.

The wear and scoring attributed to particles from the damaged cylinder that was replaced the previous evening were not considered to be of sufficient magnitude to have resulted in a power loss. Because the governor was found serviceable when tested, the possibility of uncommanded feathering was discounted.

The only malfunction found which would have necessitated an engine shutdown was the fracture of the flange attachment bolt, the cause of which could not be determined. The effect of this fracture could manifest itself in two ways: the loss of torque on the mating plates would have resulted in propeller tip track loss or wobble; or the head of the broken bolt would have alternately jammed and released between the crankshaft flange and the crankcase housing. Either condition would have resulted in engine vibrations of sufficient magnitude to cause the pilot to shut down the engine.

2.3 Pilot Reactions

Following the engine shutdown, the aircraft entered a spin from an altitude of approximately 500 to 600 feet agl, which was too low to effect spin recovery. The spin occurred because the pilot was unable to maintain flying speed while operating the aircraft on one engine. According to the aircraft operating manual, the aircraft should have been capable of maintaining flight, but, because of the near gross weight of the aircraft and the atmospheric conditions, there would have been little margin for error. The situation required precise handling by the pilot to maintain flying speed and aircraft control.

The stall speed of the aircraft could increase above that of the Vmc speed with the factors present at the time of the occurrence. Turbulent weather conditions would cause a change in the aircraft's altitude, attitude and airspeed. An increase in the aircraft's pitch or bank attitude, coupled with the airspeed variations, would increase the possibility of the aircraft stalling. The severity of the single engine stall characteristics would give the pilot little chance to effect a safe recovery.

Because of the pilot's memory loss, not all of his reactions to the emergency are known. It is known that he feathered the left engine, made a radio transmission, retarded a throttle, and selected the left magneto switch to the OFF position. These actions could have preoccupied the pilot to the extent that he did not monitor airspeed and aircraft control to the required degree of precision.

The pilot had been on duty one hour at the time of the occurrence, before which he had been off duty for 16 hours. Acute or short-term fatigue is therefore not considered a factor in his performance.

The pilot's long-term flying rate was high. He had flown 410.1 hours in the preceding 90 days, and he had flown 372.3 hours since joining the company 67 days prior to the accident. During that period, the pilot had only two non-flying days. The company operations manual limited flying time to 120 hours in any 30 consecutive days and to 300 hours in any 90 consecutive day period. The flight time accumulated by the pilot was in excess of these limitations. It is probable, therefore that the pilot was suffering from chronic fatigue, but the extent of its effects on his performance during the emergency could not be determined.

3.0 CONCLUSIONS

3.1 Findings

1. The pilot feathered the left engine.

2. A fractured flange attachment bolt caused a vibration in the left engine. The cause of the bolt fracture was undetermined.

3. In the existing atmospheric conditions, the aircraft was capable of a climb on one engine with precise handling by the pilot.

4. The pilot was unable to maintain flying speed while operating on one engine, and the aircraft entered a spin at low altitude.

5. The flight time accumulated by the pilot was in excess of the limitations specified in the company operations manual.

6. It is probable that the pilot was suffering from the effects of chronic fatigue, but the extent of its effects on his performance could not be determined.

7. The pilot was certified and qualified for the flight in accordance with existing regulations.

8. The oil screens and sumps were not inspected for foreign objects following a cylinder change, as is standard industry practice.

9. The weight and centre of gravity were within the prescribed limits.

3.2 Causes

The pilot was unable to maintain flying speed while operating the aircraft on one engine. A vibration induced by a fractured flange attachment bolt probably led the pilot to feather the left engine.

4.0 SAFETY ACTION

4.1 Safety Concern

4.1.1 Pilot Fatigue

In 1985, due to concern regarding the frequency with which fatigue was identified as a contributing factor in aviation accidents, the Canadian Aviation Safety Board (CASB) conducted a study of 67 such cases recorded between 1976 and 1984. The study focused on three major issues i.e. chronic fatigue, acute fatigue, and crew rest; in 1986, six recommendations (CASB 86-11 to 86-16) were issued. Between 1985 and 1989, an additional 14 accidents occurred in which fatigue was assessed to be a contributing factor.

This latest accident is an example of the possible effects that chronic fatigue can have on pilot performance. Since he joined the company 67 days previously, the pilot had only two non-flying days. His accumulated flying time of 372 hours over this period and 410 hours in the 90 days preceding the accident must be considered excessive. Furthermore, considering non-flying duties, the accumulated flight time is not indicative of the pilot's total workload.

For several years, the Department of Transport has been attempting to define adequate regulations which balance the dictates of safety with company operating requirements and administrative ease of implementation. A Health and Welfare Canada study on Flight Times and Flight Duty Times in Canada completed in 1988 proposed regulations which would permit 180 hours flying time in any 30 day period and 450 hours flying time in any 90 day period. Such regulations would have been totally ineffective in reducing the effects of chronic fatigue on this accident pilot.

In the light of accidents such as this one, the Board continues to have strong reservations about the adequacy of regulations regarding flight and duty time limitations and minimum crew rest provisions. Clearly the pernicious effects of chronic fatigue on flight crews are not well understood by pilots, by company management, or by the regulatory authorities.

4.1.2 Pilots' Operating Manuals

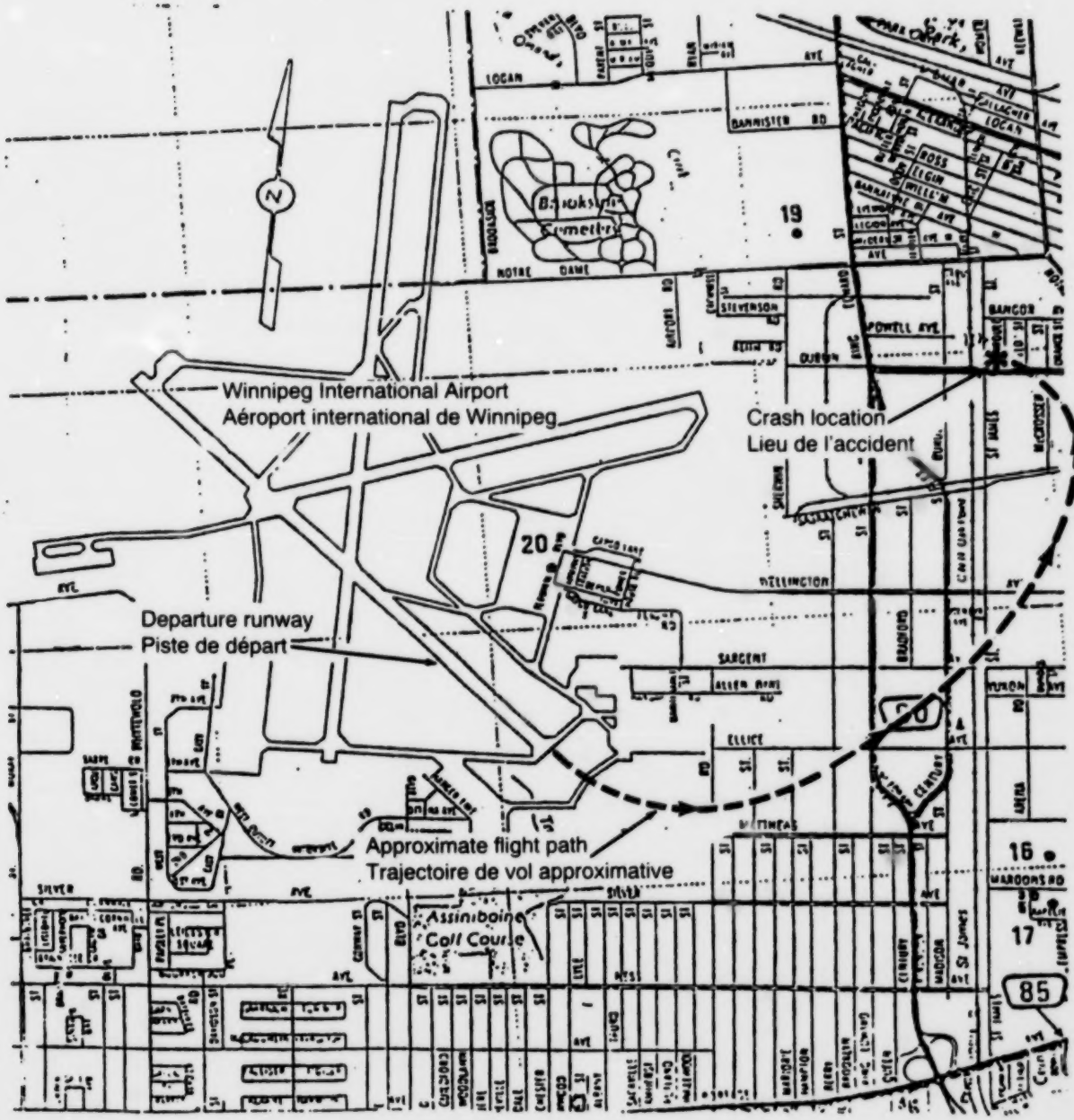
Over the years, the Board has noted that Pilots' Operating Manuals for light multi-engine aircraft are often vague with respect to single-engine performance data and characteristics - particularly older Pilots' Operating Manuals. Given the marginal handling capabilities of many light twin-engine aircraft, general guidance to pilots in terms of Cautions, Warnings and recommended recovery procedures could help compensate for these shortcomings. For example, Warnings with respect to the violent nature of single-engine stalls, the effects of maintaining five degrees of bank into the dead engine, expected altitude losses in the event of a single-engine stall, the adverse effect of turbulence on single engine performance, etc. may be instructive to pilots under the circumstances of the accident flight. Furthermore, given the criticality of single-engine performance, Pilots' Operating Manuals should be precise with respect to whether the published airspeeds are IAS, CAS, knots, or miles per hour.

Since the fare-paying public is not generally aware of the limited single-engine performance capabilities of many twin-engine aircraft, and since many of these aircraft are operated by relatively inexperienced pilots, the Board believes that Pilots' Operating Manuals should be absolutely clear with respect to single-engine performance capabilities and characteristics. The Board intends to monitor occurrences involving single-engine performance on this class of aircraft vis-à-vis the adequacy of the information available to pilots in the Pilots' Operating Manuals.

This report and the safety action therein has been adopted by the Chairman, J.W. Stants, and Board Members:

G.E. Bennett
Z.M. Brunet
W.R. Dupont
H.M.D. MacNeil

AIRCRAFT FINAL FLIGHT PATH
TRAJECTOIRE DE VOL FINALE DE L'AVION



GLOSSARY

agl	above ground level
asl	above sea level
C	Celsius
CDT	central daylight time
CAS	calibrated air speed
CASB	Canadian Aviation Safety Board
ft	feet
hr	hour(s)
IAS	indicated airspeed
kt	knot(s)
lat	latitude
lb	pound(s)
long	longitude
mi	mile(s)
N	north
UTC	Coordinated Universal Time
Vmc	minimum control speed
VFR	visual flight rules
W	west
°	degree(s)
'	minute(s)